Research
FOR FARMERS

WINTER—1961

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CANADA DEPARTMENT OF AGRICULTURE

Research FOR FARMERS

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CANADA DEPARTMENT OF AGRICULTURE
Ottawa, Ontario

HON. ALVIN HAMILTON
Minister

S. C. BARRY
Deputy Minister

WINTER — 1961

Vol. 6 **No. 1**

"*Research for Farmers*" is published quarterly by the Canada Department of Agriculture. Its purpose is to help keep extension workers informed of developments in research and experimentation as carried on by the various units of the Department.

Extension men need advance information

As the new Minister of Agriculture, I welcome this opportunity to greet the host of provincial extension specialists and others who receive "Research for Farmers".

As the masthead clearly states, the purpose of this publication is to help keep extension workers informed of developments in research and experimentation as carried on by the various units of the Department.

I am particularly gratified to note the favorable comments from an opinion poll on "Research for Farmers" conducted during the summer of 1959. The survey, made after three years of publication, of provincial extension directors and field staffs, revealed that, in their opinion, the quarterly was serving a useful purpose and should be continued—with emphasis on providing advance information to the extension workers so that they may better serve the farmer.

Over the years, I have become acquainted with many provincial extension workers and federal research men. I am aware of the former's need for advance information on current problems under study, and I can appreciate the researcher's reluctance to give it until all the strings of his research package have been tied. However, our research people realize that the federal-provincial gap on agricultural research information must be bridged. In this connection, we are urging our authors to take the readers into their confidence and put the extension people in a better position to interpret our objectives to the farmers they serve, by reporting on progress being made in meeting these objectives, and on what the future course is to be. This gives an opportunity to deal with the challenge, achievement and promise of specific Departmental research or regulatory efforts.

It is my earnest hope that "Research for Farmers" will continue to help our readers keep in touch with interesting developments in our program.

ALVIN HAMILTON,
Minister of Agriculture.

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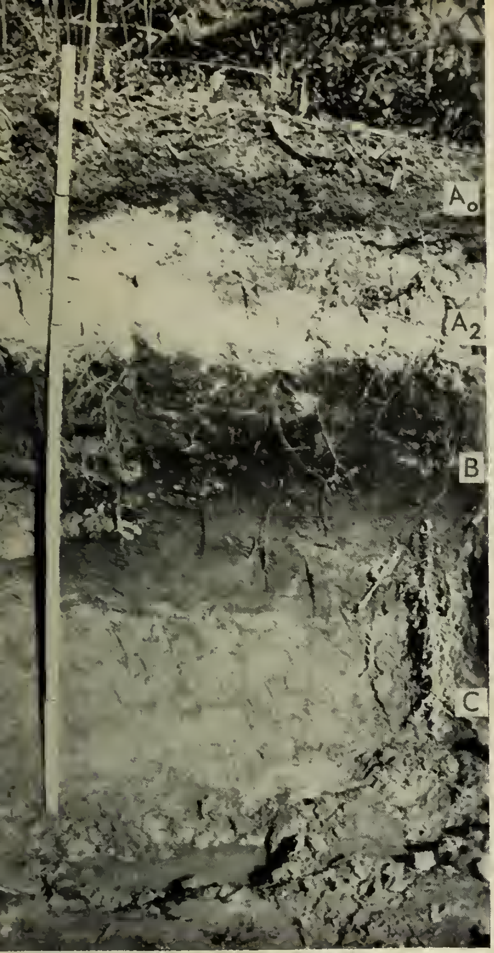
Cover photo: **Scientist studying horizons of podzolic soil profiles to explain their genesis and classification. (See story, page 3.)**



Natural podzol profile showing distinct horizon differentiation.

The Puzzle of Podzolic Soils

These soils often require costly fertilizer and management practices. To better understand them is of scientific and economic interest.

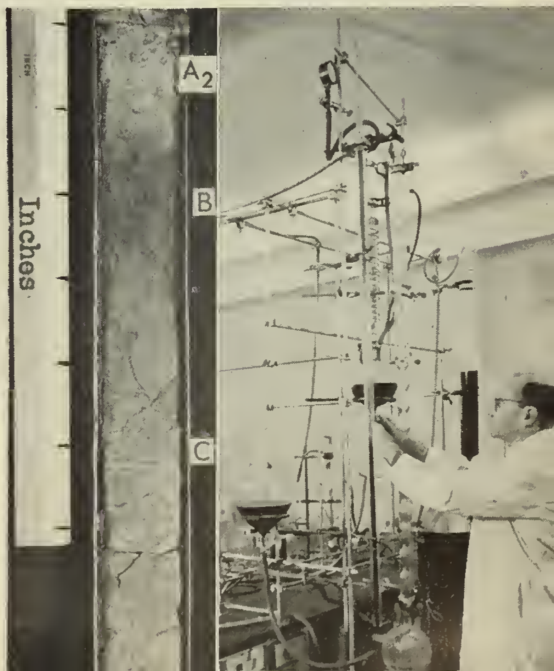
J. R. Wright and M. Schnitzer

Chemists of the Department's Soil Research Institute at Ottawa, amongst other projects, are trying to figure out the processes that go into the making of podzolic soils—those with impoverished, grayish layers near the surface that are brought to light by the plow and which often require costly fertilizer and management practices. Podzolization is certainly the most widespread soil-forming process in Canada and in many regions the dominant one. Many of the problems limiting optimum productivity of Canadian soils result directly from this soil-forming process. The low fertility of many soils is due to extensive leaching and their acid reaction. Because of this, deficiencies of nutrients essential for plant growth often occur. In some soils podzolization leads to the formation of impervious layers in the subsoil thus impeding drainage and root penetration. A better understanding of podzolization is therefore not only of scientific but also of economic interest.

In this article we shall consider *podzolization* as the fundamental soil-forming process for all podzolic soils although there will be variations in the appearance of the soil profile due to physical and chemical characteristics. For example, in the Gray-Brown Podzolic and Gray Wooded soils the leaching and subsequent accumulation of organic matter, iron and aluminum, in the subsoil is less pronounced than in well-developed Podzols but clay movement and clay accumulation layers are more evident. Also these podzolic soils are less acid than mature Podzols. One might expect, however, that a continuation of the present environmental conditions would in time result in the formation of well-developed Podzols.

Podzol soils develop in moist cool climates under forest or heath vegetation. These climatic and biologic conditions favor the accumulation of an organic surface layer (see Ao horizon illustrated) and the formation of acidic decomposition products of the organic matter. The Ao is underlain by an ashy-gray leached horizon (A_2) which has become deficient in bases and has lost relatively more iron and aluminum than silica. The A_2, in turn, is underlain by a darker colored layer (see B horizon illustrated) in which the major products of accumulation are iron, aluminum and organic matter. In general, the soil is acid

Co-author Schnitzer adjusting apparatus for purification of the "active" organic matter extracted from a podzol soil. *Inset:* Podzolic profile developed in the laboratory by leaching calcareous sand with ethylenediamine-tetra-acetic acid.



The authors are specialists in soil genesis with the Soil Research Institute, Ottawa.

and low in bases. The downward movement of organic matter, iron and aluminum from the upper horizon and their accumulation in the B is the most characteristic feature of all podzolic soils.

It has long been asserted that the organic matter leached from the surface layer is responsible for the movement of iron and aluminum. Unfortunately, the reactions between the organic matter and the inorganic soil materials are not yet well known. In order to throw some light on this situation, we thought it essential to first obtain more specific information on the chemistry of the organic matter "active" in podzolization.

In order to separate the organic from the inorganic soil material, we tested a large number of extractants. The organic matter of the B horizon was considerably more soluble in all extractants than that of the Ao. This was especially so in dilute inorganic acids. An examination of the extracted materials by infrared spectroscopy indicated that the extracted B material (the "active fraction") contained more hydroxyl[1] and carboxyl[1] groups per gram of organic matter than the extracted Ao material. There were also indications that the carboxyl groups were associated with metals, suggesting that the reactions took place through these groups.

As our experiments progressed the following questions arose: what kinds and how many active groups were involved and to what type of chemical structure were these groups attached? In order to find an answer, we carried out active group analyses and oxidative degradations (breaking up the molecule by oxidation) of these materials. As much as 60 per cent of the organic matter of the B horizon could be accounted for as carboxyl, hydroxyl and carbonyl groups. The carboxyl groups constituted about two-thirds of this value. On the other hand, the active groups in the extracted Ao material accounted for only 30 per cent of the organic matter. The biggest difference between the two materials was in their carboxyl content which was four times higher in the B than in the Ao organic matter.

All of these groups are known to react with metals commonly encountered in podzolic soils and therefore could conceivably account for the effectiveness of the B organic matter in podzolization. The oxidative degradation of these materials produced a number of organic acids. From the relative ratios of these acids we concluded that the B organic matter had primarily a ring (aromatic) structure while the Ao material contained straight chain (aliphatic) in addition to ring structures. These experiments indicated that the organic materials most likely responsible for the complexing and movement of metals such as iron and aluminum consisted primarily of rings to which the active groups, particularly carboxyls, were attached.

The next problem was what type of bonding occurs between this "active" organic matter and the inorganic soil constituents such as metals, metallic oxides and clays? In order to elucidate these phenomena, we are initiating investigations on the interaction between the "active" organic matter extracted from both horizons and pure solutions of metals and suspensions of clays. Ultimately it is proposed to demonstrate in the laboratory that leaching a soil parent material with a solution of the "active" fraction of podzolic organic matter will in fact produce a podzol soil having the same appearance and chemical characteristics as naturally occurring ones. We have already produced a podzolic profile in the laboratory by leaching a column of sandy calcareous parent material with the known metal-complexing agent ethylenediamine-tetra-acetic acid. We hope that such studies will yield valuable information about the organo-metallic reactions involved and the mechanisms operating in the formation of podzols and other podzolic soils.

Podzolic Soils – Four Distinct Groups

Dr. P. C. Stobbe, Director of the Soil Research Institute describes these soils as follows:

"Four distinct great groups of Podzolic soils have been recognized in Canada, the "Gray Wooded", "Gray-Brown Podzolic", "Podzol", and "Humic Podzol" groups.

"The Gray Wooded soils have developed under cooler conditions where precipitation is more effective than on the grassland. Under undisturbed conditions they have a leaf mat over a distinct gray leached layer which in turn is underlain by a darker subsurface horizon enriched mainly in clay. The surface and subsurface layers are moderately to slightly acid and moderately well supplied with bases; the subsoil is generally calcareous.

"The Gray-Brown Podzolic soils have developed under warmer climatic conditions and they differ from the Gray Wooded soils mainly in that the upper part of the surface layer consists of a dark, friable mineral-organic soil, slightly acid to neutral in reaction and moderately well supplied with bases. The formation of this layer seems to be closely associated with the higher biologic activity, particularly of earthworms, under the more temperate conditions.

"In the Podzol group the gray layer near the surface is more strongly weathered and leached than in the Gray Wooded soils and the accumulation products in the subsurface consist dominantly of organic matter and sesquioxides. These soils are moderately to strongly acid and have a low degree of base saturation.

"The Humic Podzols have developed under the more humid and cool conditions and under a heath-type of ground-cover; consequently they have a thick organic mat on the surface. The accumulations in the subsurface are dominantly organic and they form a dark layer that generally contains more than 10 per cent of organic matter. These soils are strongly acid and highly unsaturated."

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[1] *Reactive chemical groups through which organic matter can be linked to inorganic soil constituents.*

Flesh fly about to deposit maggot on grasshopper.

Can the Grasshoppers' Natural Enemies Stop Them?

While natural enemies have not prevented grasshopper outbreaks, they reduce grasshopper abundance.

R. W. Smith

GRASSHOPPER numbers fluctuate in response to a changing complex of factors of which natural enemies and weather are most important. These factors and the complexes of grasshopper species themselves vary in quality and quantity with time and place. The newer insecticides reduce populations in particular stands of crops but leave hazardous residues and apparently have little effect on the general levels of grasshopper abundance.

The Entomology Research Institute for Biological Control at Belleville, Ont., is studying many natural enemies of grasshoppers that feed on the eggs and attack the nymphal and adult grasshoppers. Predators of the eggs include bee flies, blister beetles, ground beetles, and a few others. They lay their eggs in the soil close to the grasshopper egg pods and when the immature stages hatch they locate the pods and feed upon the eggs. The bee-fly maggots are the most important of these, followed by the young of the blister beetles and ground bettles. Unfortunately, the adult blister beetles are leaf-feeders and when abundant are serious pests of plants. This group of predators may destroy up to 80 per cent of the eggs in limited areas. Even the black field cricket was found to destroy 50 per cent of the eggs in some situations.

Small wasp-like insects of the genus *Scelio* parasitize the grasshopper eggs just after they have been laid. The young complete their development in the grasshopper eggs and produce adults in time to parasitize the following generation. They have been known to destroy 5 to 40 per cent of the eggs.

The Research Institute is also investigating other natural enemies of grasshoppers, namely, flesh flies, tachinid flies, muscid flies, tangle-veined flies, threadworms, spiders and diseases.

The flesh flies, of which there are at least 20 kinds in Canada, deposit tiny living maggots on grasshoppers while the latter are active on the ground or on the wing. Our investigations show that the maggots work their way with their sharp mouth hooks into the grasshoppers through the softer membranous areas, feed on the insides and eventually kill their hosts. Some species of flesh flies have piercing organs for placing their maggots inside the grasshoppers. The flesh flies have more than one generation a season and pass the winter as full grown maggots in the soil. Some species attack the younger grasshoppers, others only the older or larger one. Together this group may effect a cumulative seasonal parasitism of 60 per cent. The species *Kellymyia kellyi* (Ald.) is credited with bringing outbreaks to an end, but

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The author is a specialist in field and pasture insect parasites at the Entomology Research Institute for Biological Control, Belleville, Ont.

Author dissecting grasshoppers from Western Canada to determine occurrence and extent of parasitism.

it is also known to be a scavenger that feeds on dead insects.

The four kinds of tachinid flies deposit eggs on the grasshoppers. The tiny maggots that hatch from these rasp their way into the host and feed on the contents, with results similar to those caused by the flesh flies. They have more than one generation a year, and pass the winter in little brown cases (puparia) in the soil. Though not so abundant as the flesh flies, we have found that the tachinids occasionally cause a seasonal parasitism of 60 per cent.

Our studies of the small muscid flies of the genus *Acridomyia* revealed that they place their eggs inside the body of the grasshopper through a small aperture made with their rasping mouth parts. The small maggots feed on the insides but do not kill the grasshopper unless many are present. They have but one generation a year and pass the winter in the soil in little brown puparia.

The tangle-veined flies, of two kinds, are large insects with a thick covering of fine yellow hair. Investigations disclosed that they do not attack the grasshoppers directly but lay many thousands of eggs in the chinks and holes in old grass heads, weeds, fence posts, and similar situations. The eggs hatch in a week or so and the tiny maggots are scattered by the wind to the surrounding vegetation. There they come in contact with grasshoppers and enter through the larger breathing pores or the membranous areas of the abdomen. The maggots of these species are distinguished by the long breathing funnels that are attached to the respiratory ducts of the grasshoppers. Large, fully grown maggots leave the grasshoppers to overwinter in the soil. They transform to adults in the spring and emerge to lay their eggs. These flies are found mostly in British Columbia and Alberta, but even there they are not particularly abundant. In adjoining Montana and Idaho, and in Oregon, they kill 80 per cent of the rangeland grasshoppers in some areas.

The Belleville Laboratory has also studied threadworms, which are occasionally found in grasshoppers in moist locations. There are two kinds though not common in Western Canada. Both are elongate worms found coiled within the grasshoppers. When fullgrown they completely fill the host. The mature worms over-winter underground and, depending on the species, lay their eggs either in the soil or on vegetation. Eggs on the vegetation are ingested by feeding grasshoppers. Worms from eggs in the soil emerge and crowl up on the vegetation during moist periods and attach themselves to passing grasshoppers. Threadworms have been found in as many as 36 per cent of the grasshoppers in certain collections.

In addition to the above there are, unfortunately, some wasp-like parasites that attack the maggots that kill the grasshoppers. We have ascertained that as many as 80 per cent of the grasshoppers in certain populations have been found with the tiny maggots of one of these wasp-like parasites lying in wait for the arrival of a fly maggot. These tiny maggots hatch from eggs laid on vegetation and attach themselves to passing grasshoppers. Other species of these parasites deposit their eggs directly into the fly maggots within the grasshopper. All these species complete their development and transform to adults after the fly maggots have left the grasshoppers and formed their puparia in the soil. These parasites do not injure the grasshoppers but they do reduce the populations of beneficial flies.

Spiders capture many young and adult grasshoppers in their webs and certain wasps use grasshoppers to provision their burrows. Crows, blackbirds, and gulls devour vast numbers of grasshoppers when the latter are present in moderate or outbreak numbers.

Some fungi and several bacteria attack grasshoppers. Our studies revealed that one fungous disease leaves the corpses of its victims clinging conspicuously to the stems of grasses, and under warm humid conditions fungi may cause epidemics and may wipe out grasshopper populations.

Only a half-dozen or so of the many bacteria found in grasshoppers are pathogenic, and these are only pathogenic if they reach the body cavity. Though often present in the gut we discovered that they cannot penetrate the wall alone but enter through injuries caused by other parasitic organisms or injuries that frequently accompany moulting. Because of the rapid disintegration or disappearance of grasshoppers killed by bacterial diseases it is difficult to detect evidence of epidemics caused by them. However, it is probable that populations suffer a considerable, though undetermined, cumulative seasonal loss from bacterial infection.

The natural enemies of grasshoppers feed and grow on the populations without let-up, and while they have not prevented grasshopper outbreaks, they hasten the end and doubtless reduce the peaks of potential grasshopper abundance. Predation and parasitism increase with increasing grasshopper abundance and the chances of destructive epidemics of disease increase with the larger populations.

Because of the widespread occurrence of the same species of natural enemies and the complexity of the changing host and enemy populations, there is at present no good prospect of utilizing these enemies to prevent outbreaks of grasshoppers.

Market Lamb Production . . .

Purebreeding vs. Crossbreeding

J. P. Lemay

MARKET LAMB PRODUCTION is the primary source of revenue in the Eastern Canadian Sheep Industry. It is desirable to have these lambs marketed off grass, and for such a program early maturity, coupled with fast growth rate, is required. High milk production and prolificacy are required in the ewe, together with good conformation in the lambs.

The production of market lambs in Eastern Canada is largely on a purebred or "graded-up" flock basis. The attempts that have been made to utilize hybrid vigor and the different qualities of the various breeds of sheep have not been based on any continuous system. In this field, the general policy is of a switch-over nature, that is the flock is graded-up by the use of rams of one breed, then if, for example, the lambs become overly large and difficult to finish, rams of a smaller breed are used until size and growthiness is lost. The carcass grades in Quebec over the past ten years have been poor and this is probably due to breeding to large type rams almost completely, and also to lack of knowledge of methods of finishing.

Since crossbreeding on a definite basis has proved so successful in other countries for the production of market lambs, we set up a planned experiment in 1956 at the Experimental Farm, Ste. Anne de la Pocatiere: 1. to compare (a) the fertility and prolificacy of purebred and crossbred ewes; (b) the crossbred lambs with the purebred lambs on weight, vigor, rate of development and carcass quality; 2. to determine the relative merits of the breeding plans tested; and 3. to establish the most desirable plan, or plans, to follow for the area in which the project is undertaken.

The crosses involved were based on the following breeds: Leicester, North Country Cheviot and Suffolk. At breeding, the purebred and crossbred ewes were randomly assigned, on an age and weight basis to representative rams, and rams were changed yearly. So far as was possible the new rams used were not related to those of the previous year. Ram lambs out of these matings were fattened and marketed. Purebred and crossbred ewe lambs were overwintered and put into the breeding lots as shearlings.

Summarizing the results of the four-year trials it appears that:

1. Crossbred lambs from North Country Cheviot rams on Leicester ewes, and from Suffolk rams on (North Country Cheviot × Leicester) ewes have proved superior to purebred Leicester lambs. The two-way cross and three-way cross ewes outyielded the purebred by 1.7 and 2.6 pounds at birth, 1.1 and 4.5 pounds at four weks, and 9.0 and 14.6 pounds at weaning. The average daily gain from birth to weaning was 0.373 pound for the purebred Leicester and 0.431 and 0.469 for the two-way and three-way crosses.

2. In mortality rate from birth to weaning, the Suffolk × (NCC×L) was the lowest of all groups 10.2 per cent.

3. Because average daily gain to weaning and weaning weight are affected by birth mate and milk production of the dam, the actual number of pounds of lamb at weaning probably the best criterion for estimating the worth of the various crosses at that age. The Suffolk-sired group was outstanding in this regard and the NCC × Leicester second.

4. North Country Cheviot- and Suffolk-sired lambs were of sufficient weight and finish to go to market ahead of the purebred Leicester. The average daily gain from birth to market was 0.370, 0.485 and 0.510 pound respectively for purebred, two-way, and three-way cross lambs.

5. Crossbred ewes have produced slightly less wool than purebreds, with the difference being less striking whenever the Leicester breed entered into the mating. Single cross NCC × Leicester produced 0.3 pound more wool than three-way cross Suffolk × (NCC × L).

Mr. Lemay is a Research Officer with the Animal Husbandry Division at the Research Station, Ste. Anne de la Pocatiere, P.Q.

Left to right: **Purebred Leicester ewes; crossbred NCC × Leicester; and crossbred Suffolk × (NCC × L) ewes.**

Quality Testing in Bree

QUALITY in cereals is a term used to summarize all the factors, the physical and chemical properties, that affect industrial processing and the nature of derived products. It is a vital factor in every type of program designed for crop improvement. While the agronomic properties such as high yield, disease resistance, ease of handling and many others are essential for the economic production of cereals, quality is the basis of sales on domestic and export markets. The basis of crop improvement is the development of new and more suitable varieties and this requires the co-operative effort of various specialists in the field of plant science. One of them is the cereal chemist, whose job in the breeding project is to ensure that only those hybrid lines having quality as good as, if not better than, that of established standards are selected and later released as varieties for commercial production.

Intensive wheat and barley breeding programs are in progress in all regions of Canada and each year crossing and selection produce a very large number of hybrid lines. Progenies, a few of which may represent considerable improvement over existing varieties, are first screened for disease resistance and general agronomic suitability and the unsatisfactory lines are discarded. Even so, a large number remain that require the cereal chemist's quality evaluation.

Many years ago improvement in quality was largely a matter of chance. Although, in fact, up to a certain point, quality improvement accompanied agronomic improvement and visual assessments generally sufficed. The late Sir Charles Saunders paid particular attention to quality and tested all

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The author is a cereal chemist at the Canada Department of Agriculture Research Station, Winnipeg, Man.

New Laboratory Flour Mill Aids

EARLY QUALITY EVALUATION of promising new wheat varieties will be facilitated by a laboratory flour mill developed by the Engineering Research Services and the Genetics and Plant Breeding Research Institute of the Research Branch. It is designed to handle 100-gram samples or less and good recoveries of flour have been obtained from as litle as 25 grams of wheat.

The mill is essentially a micro flour mill. The compact features, with provision for cleaning between samples, keep milling losses low and ensure against contamination of one sample with another. Milling yields vary with the kind of wheat being milled. Recovery of flour has varied from 60 to 70 per cent for hard wheats and 55 to 65 per cent for soft wheats. Thus, the mill will give information on the milling characteristics of varieties based on yields of bran, shorts, and flour. The most important feature, however, is the ability to mill large numbers of samples in a short period for subsequent small-scale quality tests on the flour. As many as 15 samples of 100 grams of wheat may be milled per hour.

The mill has many of the features found in commercial flour mills which include four stands of rolls with two break pairs and two reduction pairs of rolls. These are mounted one above the other with a bran bolter below the second break roll unit and a flour bolter at the bottom of the mill. Each pair of rolls has one roll in a fixed position while the other roll is spring loaded to facilitate accurate setting of the rolls for the efficient milling of the wheat samples. These rolls turn in oil-sealed roller bearings. The rolls are grooved to receive divider plates which divide the mill into sections to accommodate the milling of four samples. The samples are fed into the top of the mill by an oscillating mechanical feeder and the four flour samples are removed from a bolter at the bottom of the mill. Three of these mills have been built and are located at Ottawa, Winnipeg and Lethbridge.

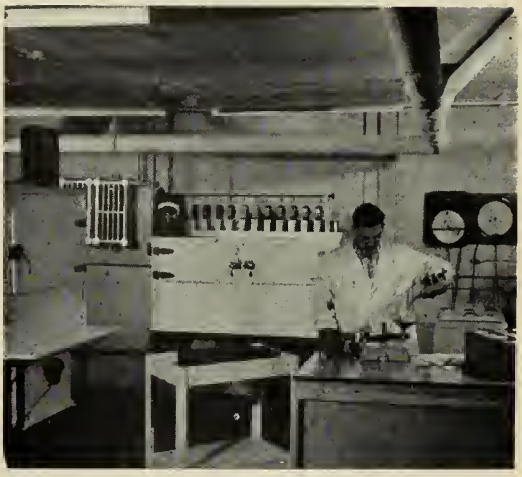
Both authors are located in Ottawa, Mr. Whiteside specializing in wheat quality at the Genetics and Plant Breeding Research Institute, and Mr. Kemp in machinery and equipment for the Engineering Research Service.

V. M. Bendelow

ing New Cereal Varieties

samples for gluten through a chewing test. Tests on new varieties were made in some cases and the trials were carried out in a commercial mill, bakery, or malthouse, using a few bushels of wheat or barley. This procedure is not feasible today. The finer points of quality of a new variety cannot be estimated simply by looking at a sample. Numerous small, local mills, bakeries and breweries have been consolidated into a few much larger efficiently operated plants where the processing of batches consisting of thousands of bushels is usual. Industrial plants cannot, therefore, be used to test selections from cereal breeding projects. It would take several years to increase a few ounces of grain to the amount required for a commercial test and only a minute fraction of the breeders' lines could be tested in this fashion. The odds against finding an acceptable line among the very few selected by chance for this test are enormous.

The first attempt to overcome this difficulty was the construction of laboratory models of mills, bakeries and malting plants and the use of them to test potential new varieties. This method has been very successful. But such equipment is very costly in space, staff and general operation and nowadays cannot be used to test every hybrid line that a cereal breeder selects from his program,



Cereal quality unit has lab. facilities for making prediction and malting tests.

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heat Research

A. G. O. Whiteside AND *J. G. Kemp*

Since the reputation of Canadian wheat is based on high quality, the value of these mills in wheat breeding programs can be readily recognized. It is of little avail to produce a good agronomic variety that fails to meet the high standards of quality first recognized in Red Fife, later in Marquis and more recently in varieties like Thatcher, Regent, Redman, Saunders, Chinook, Canthatch, Selkirk and Pembina. The late Sir Charles Saunders recognized the need for selecting for quality early in his breeding programs when he applied his famous chewing test. While quality evaluation has advanced to more precise methods since this early period, nevertheless the principle still stands that it is better to screen for quality early in the breeding program and concentrate on the more promising material than to carry poor-quality wheats to the more advanced stages of testing. The volume of material which it will now be possible to handle should be greatly facilitated by these new laboratory flour mills.

Genetic studies on wheat quality will also benefit from this new equipment since large numbers of samples are usually required in determining the

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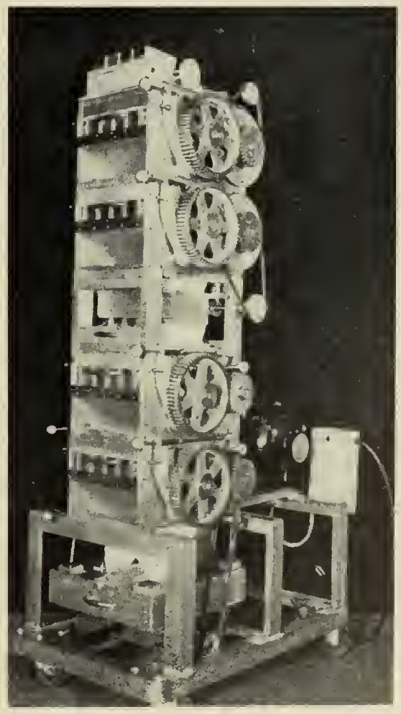


New laboratory flour mill will assist wheat improvement work.

especially as breeding projects expand each year. The odds against finding the right variety are still high. Even assuming that sufficient laboratory equipment and staff could be made available, the space, time and effort required by the plant breeder to produce enough of each hybrid line would be prohibitive. If this were the only method of quality evaluation, then breeding programs would have to be scaled down, thus reducing the effectiveness and chances of success of cereal crop improvement projects. Laboratory equipment for milling, baking, malting and brewing that gives a reasonable imitation of industrial performance has a place in the scheme of testing for quality but not at the preliminary selection stage.

The answer lies in some technique that requires a minimum of time, is not too complicated, and can be applied to very small grain samples, for example the amount that is available by the third or fourth generation of a crossing program. By then the more obvious agronomic characters have generally been established and it is an optimum stage at which to reduce the hybrid population by selecting out the lines of better quality. The plant breeder can thus be saved the trouble and expense of work on many lines that have no chance of acceptance by cereal consuming industries.

Suitable techniques meeting the above requirements have been developed and are known as "prediction tests". They are the result of what has been called correlational research, that is, an investigation of processing characteristics and the characteristics of the finished product and their relation to various properties of the raw material, wheat and barley. All types of physical and chemical tests that have the slightest possibility of being of some value are tried and those that appear to have any direct or indirect bearing on industrial properties of wheat or barley are thoroughly investigated. Comparison of the results of these tests over a period of years with actual bread-making or malting quality determines their utility. This approach has been very rewarding and a number of

What Are Prediction Tests?

Prediction tests are laboratory tests, mostly of a chemical nature, that are used early in a cereal breeding program to screen hybrid populations in order to eliminate poor quality lines. They are short cuts that do not necessitate the actual malting of barley, the baking of loaves from wheat flour or the making of macaroni from durum wheat.

Prediction tests do not require complex and expensive equipment necessary for malting, baking, etc. Prediction test apparatus is almost entirely of a simple, easily constructed type.

The analytical determinations are such that large numbers of samples can be tested in the period between harvest and seeding.

The prediction test can be used at a very early generation in the breeding project, say at F3 or F4, and only a small sample is required.

Briefly the techniques for barley, common wheat, and durum wheat prediction tests are:

Barley: The prediction test involves analytical determinations of nitrogen content, potential extract and saccharifying activity. Low nitrogen (protein) content is desirable in malting barleys. The barley extract is determined by allowing a milled barley sample to react with a mixture of diastatic enzymes overnight, followed by a controlled hot water extraction. The percentage of material made water-soluble by this procedure is closely related to the amount of extract that would have been produced had the barley been made into malt. Saccharifying activity is related to general enzymatic activity and is determined by activating the enzyme (beta amylase) in a ground barley sample with a solution of papain and measuring the amount of sugar formed by the action of the resulting infusion on starch. The barley value is a very good estimate of malt saccharifying activity when properly interpreted.

When data from these three determinations made on hybrid lines are compared with data obtained on standard varieties, whose quality is established, the lines are either rejected or retained for more detailed examination (i.e. an actual malting). This technique has, in the past decade, rejected about 80% of the samples submitted for quality tests. All "borderline" cases and where any doubt at all exists, are retained for malting.

Common Wheat: The prediction test consists of milling a sample of 80-100 gm. of wheat in a micro-mill, measuring the amount of flour and other products, observing the general milling behaviour and then making two determinations (an expansion test and a sedimentation test) on the flour. These determinations are closely correlated with the quality of the flour protein (and through this to dough and bread processing properties) and to the important loaf volume factor. As in barley, data on hybrid lines are compared with data on standard, acceptable varieties that were grown alongside the hybrid lines.

Durum Wheat: The prediction test required only 20 gm. of wheat. Wheat pigment content is determined (as beta carotene) on a ground sample, and, as lipoxidase is probably responsible for loss of pigment during macaroni processing, the activity of this enzyme in the wheat sample is also measured. Using a regression equation, the predicted macaroni pigment can be calculated from the wheat data. Additional quality information is also often obtained by visual examination of the properties of of the gluten washed out of a wheat sample. Once again, results are compared with values obtained on standard varieties and the hybrids either rejected or retained.

All these analytical techniques were developed and correlations established on the basis of comparison with hundreds of actual malting, baking, etc. tests.

satisfactory prediction tests have been developed, especially in the case of barley, where they have been used to good advanctage for several years. The value of prediction tests can best be illustrated by an example. Barley breeding programs in Canada at present produce each year between 1,000 and 2,000 hybrid lines that appear to be agronomically promising and require quality evaluation. Industrial tests of so many lines are out of the question. Laboratory pilot malting and brewing equipment that is available might be able to test 50 lines, but this would present several problems. The smaller-scale malting equipment at Winnipeg could process possibly 400 samples, but this is time-consuming, requires at least 1½ lb. of barley per test, which is a burden on the plant breeder, and still leaves a lot to chance. Using the barley prediction quality test, which requires only two ounces of grain, and which does not involve malting, the Winnipeg laboratory can easily check the whole set of 1000 to 2000 lines during the year. The chance factor is removed and a two-ounce sample presents no problem to the plant breeder. Thus a cereal breeder can be advised at an early generation stage whether or not he is on the right track as far as quality is concerned. His program can be changed accordingly and very little time will be wasted. The production of new varieties is speeded up and the quality evaluation of material used in breeding or produced as a result of breeding is more efficient.

The considerable advantage of obtaining information on quality as early as possible in the cereal breeding program prompts a continual search for more discriminatory and thus more efficient testing methods and equipment. A recent development in wheat quality testing is an example of the progress being made toward greater efficiency. In the original prediction test method, the small wheat sample was finely ground and measurements related to quality were made on the whole meal. Although better than no test at all, this procedure was not entirely satisfactory. Baking properties depend on flour produced by milling rather than on whole meal produced by grinding. The problem was that there was no mill available that would rapidly process a large number of small-sized samples. This has now been overcome. In 1959, Research Branch engineers at Ottawa completed the development of a flour mill (see accompanying article) that processes simultaneously four wheat samples, each weighing as little as 3½ ounces. For this amount of wheat the milling time is about 10 minutes. The resulting flour is comparable to that produced in commercial mills and is very satisfactory for quality evaluation tests. The mill fulfills the prediction test requirements of small sample and rapid operation and offers a bonus in that it provides some information on milling characteristics of the wheat types. With its aid, the quality laboratory is able to provide wheat breeders with preliminary quality information on several thousands of wheat hybrid lines per year, and this is a significant step forward.

The preliminary prediction test is essentially a rejection rather than an acceptance test; it is not used to make pronouncements on quality that are in any way conclusive, but primarily to discard the lines that have no chance whatever of being accepted as varieties by commercial interests. The lines not rejected by the prediction test, which are very often only a small proportion of the samples examined but always include borderline cases, are recommended for more detailed study. The cereal breeder increases in the field those of his lines that have some promise of quality until he has enough material for the second stage of quality testing. Then the barleys are made into malt, the durum wheats into macaroni, and the common wheats milled in a larger mill to provide flour for detailed baking tests. The data obtained over a period of two or three years at this second stage are more critical and much more comparable with industrial properties than are the indirect relations of the prediction test. Lines selected as promising at this stage have an excellent chance of becoming acceptable varieties. The original hybrid populations have now been reduced to a point where few, if any at all, remain. But the few are the best and they are worth the trouble and expense of a third and final testing in a pilot-plant or on a commercal scale.

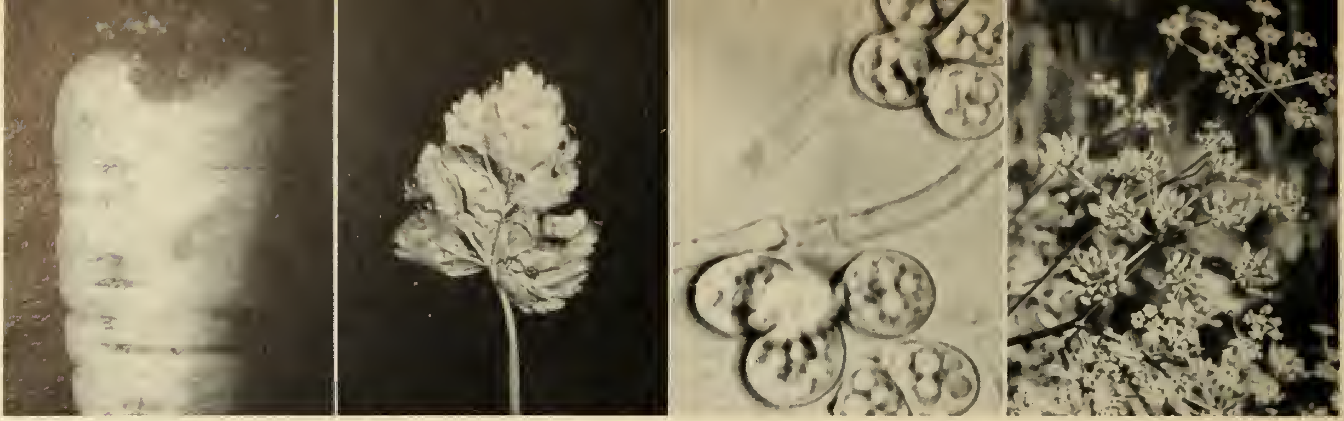
Prediction tests for cereal breeders are made on barley and durum wheat at the Winnipeg laboratory and on common wheat at the quality laboratories at Winnipeg, Ottawa and Lethbridge. Though they are only a part of the scheme of quality testing of new cereal varieties in Canada, prediction tests are vital to crop improvement. Without them the chances of producing good quality varieties would be small indeed.

Testing the dough properties of flour made from small samples of hybrid wheat lines. This is the expansion test; flour was milled in the newly developed micro-flour mill.

New Lab. Flour Mill Aids Wheat Research

from p. 8

inheritance of the various components that make up quality. A recent study of one combination between a high quality variety and a poor quality wheat indicated that the chance of recovering good quality was nil. In another similar combination only 2 per cent of the population could be expected to yield high quality varieties in conjunction with good agronomic characters. Such information provides knowledge on the complexity of the inheritance of quality characteristics. As well, it assists in planning the approach for the breeding of better agronomic varieties of good quality.



Left to right: **A canker developing from an infection on the crown. Seedling leaflet showing necrotic spots produced by inoculation with fungus spores. Spores produced in culture by *Itersonilia perplexans.* Inflorescence of wild parsnip, a carrier.**

PARSNIP CANKER

K. M. Graham

In recent years parsnip canker has invaded crops of this valuable Canadian fall vegetable in the Dixie muckland area near Toronto and the Maugerville truck-crop area along the St. John River near Fredericton, N.B.

Parsnip growers sometimes have little warning that canker is present in their produce until the roots have been in storage for some time or after they have been on display in pliofilm bags in supermarkets. Then a dry chocolate-brown rot with a sunken border encircles the crown and extends over the surface of the parsnips and renders them unsaleable. Earlier in the season the disease appears on the leaves producing silvery-green patches with killed tissue in the center and surrounded by light green borders. Occasionally in very wet years the leaf-spot phase can be sufficiently severe to defoliate plants by mid-September. Other relatively harmless diseases, however, cause similar spots on the foliage and their presence cannot always be regarded as a forerunner of the development of canker on the roots.

The causal organism is *Itersonilia perplexans,* a fungus with some relationship to the rusts and smuts. It produces its spores on the surface of the lesions on the leaves. A special mechanism releases the spores forcibly from their launching pads or "sterigmata" by means of the exudation of very small droplets of water. These "ballistospores" blow about and eventually lodge in the depressions of the crown of the parsnip, where they germinate and grow into the tissues. They may also filter down into the soil around the tap root and penetrate the parsnip in the lateral depressions out of which the feeding rootlets emerge. Rust-colored streaks are formed that enlarge to form cankers.

Suspected Carriers

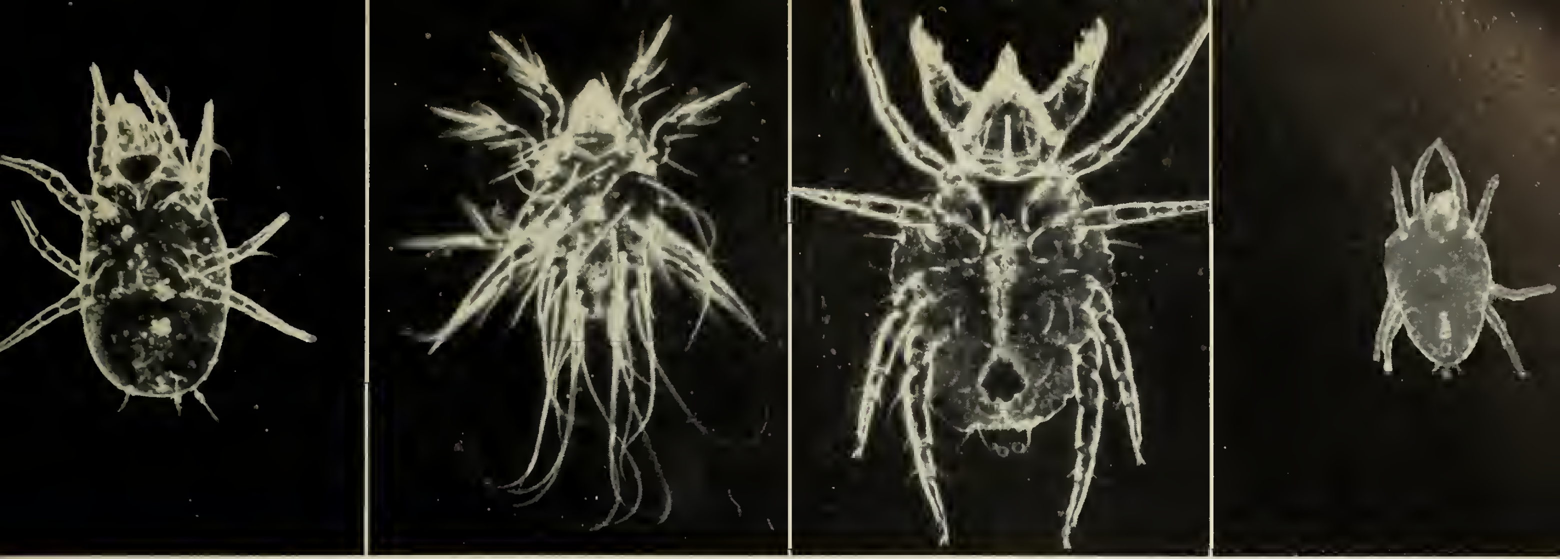
The disease has also been detected on wild parsnip, a common weed along roadsides, railway embankments, river banks and ditches in Eastern Canada. In the Fredericton area, its occurrence near fields of cultivated parsnips makes it a suspected carrier. We are not yet sure of its persistence in soil and on refuse from the harvested crop. Common perennial weeds around vegetable fields could be harboring the fungus and would bear further investigation. Dr. W. E. Sackston, formerly of the Research Station at Winnipeg, isolated the same fungus from sunflowers and he found that his culture could attack seedlings of corn, carrot, cucumber, flax and oats. In other countries, the fungus has been found on chrysanthemums and dahlias but the ability of these isolations to attack parsnip was not demonstrated. It is probable that the organism exists as a complex of strains indistinguishable from each other except by their ability to attack certain hosts.

Records of occurrence of canker indicate that it is sporadic, i.e., it may not occur consistently one year after another. In England it is severe in wet seasons, but not so bad in dry ones. However, it may appear at the end of a dry season on roots dug in November. In New York and neighbouring states, the observation has been made that a cool damp season favors its development. In Canada, it occurred in 1959 in the Fredericton area in a wet fall preceded by a warm summer but it did not recur in 1960 after an exceptionally dry season. There is apparently an increasing risk of canker infection after frost has weakened the resistance of the crowns.

Control

Well defined control measures must await further research on the timing of the first infections of the foliage in the spring, on the host plants other than parsnip and on the survival of the fungus in crop debris and in the soil. The evidence indicates no clear-cut varietal resistance or susceptibility. If the leaf-spot phase becomes severe it may be controlled by applications of a spray or dust containing a fixed-copper fungicide. Wild parsnips should certainly be eliminated from the vicinity of parsnip fields, because these weeds are proven sources of infection. If the market permits, early digging of the roots in late September or early October may salvage a large percentage of the crop in infested areas.

The author is a plant pathologist with Department's Research Station at Fredericton, N.B.



Left to right: Common grain mite (110 X); long hairy mite (108 X); cannibal mite (125 X); and a Tydeid mite (130 X).

MITES

IN

Farm-Stored Grain

R. N. Sinha

Sampling farm-stored grain at various depths to determine temperature conditions and levels of mite infestations; probe rods and thermocouples with potentiometer are shown.

MITES frequently infest stored grain on farms in Canada. Owing to their minute size, barely detectable by the unaided eye, they often remain unnoticed until a heavy infestation develops and the grain becomes tainted with a pungent musty odor.

Common rodent mite (66 X).

At least twenty different species of mites are found in Canadian grain. Two of these, the grain mite, *Acarus siro* L., and the long hairy mite, *Glycyphagus destructor* Schr., can cause heavy and widespread infestations.

These mites, feeding on broken kernels and grain dust, may bring about a slight rise in the temperature and moisture content of the grain. The main damage, however, is caused by the fact that the mites encourage the growth of harmful storage molds, such as *Penicillium,* which in turn induce sudden heating associated with a sharp rise of the grain moisture. Most mites are unable to penetrate the grain if the seed coat is undamaged, but usually less than 10 per cent of the grain has an intact bran envelope.

In our investigations at the Canada Agriculture Research Station, Winnipeg, Man., we tested the overwintering ability of several stored grain mites in three unheated small bins containing wheat and oats on Manitoba farms. Although all mites could successfully overwinter in grain the common grain mite was the most cold hardy and the cannibal mite the most susceptible to cold. In a laboratory experiment we found that the mites[1] could withstand direct exposures to 0°F. for up to 7 days.

During 1959-60 at Winnipeg, we observed the course of mite infestation in a wooden granary containing 500 bushels of wheat (Figs. 1 to 3). Wheat harvested in Sep-

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Dr. Sinha is an entomologist at the Canada Department of Agriculture Research Station, Winnipeg, Man., and specializes in mites infesting stored grain.

[1] Grain mite; long hairy mite *Glycyphagus destructor* (Schr.); cannibal mite, *Cheyletus eruditus* (Schr.); common rodent mites, *Haemolaelaps casalis* (Berlese) and *H. glasgowi* (Ewing); and Tydeid mite, *Tydeus interruptus* Sig. Thor.

tember, 1959, was purchased from a local elevator and was stored at 13.4-14.1 per cent moisture content in November, 1959. Grain temperature and moisture content at fixed sampling locations were recorded monthly. The mites were extracted and counted from 150-gram samples. Figure 1 shows that the grain had scarcely any infestation of mites. In the following June the infestation was heavier (Fig. 2). The moisture content was slightly higher due to the movement of the air moisture towards the surface of the bulk during the preceding winter. Figure 3 shows how this infestation became heavy and widespread with more than 20 mites per gram of grain in some areas by October, 1960. The grain temperature ranged from 45 to 70°F., the moisture content ranged from 13 to 14.2 per cent. Thus, wheat stored at a moisture content of 13 to 14.6 per cent at 50° to 70°F. and left undisturbed is still liable to heavy mite infestation in less than one year under the prevailing weather conditions of the Prairies. It is obvious that the common grain mite and the long hairy mite can heavily infest "straight grade" (below 14.6 per cent moisture content) grain in small bulks several feet below the surface.

From our studies on the prevention and control of stored-grain mites on farms, it is recommended that crops be harvested as dry as possible; that the grain be cleaned and dried before storage if necessary and possible; that the inside and the surroundings of the granary be kept clean (sweep walls and floors of empty granaries and apply bin spray—1% lindane or 3% malathion, or 5% methoxichlor—before storage); and that if grain with 13 per cent or more moisture content is stored, take samples every 2-3 weeks and examine them with a hand lens (10X) for mites. If mites are present, rake the top of the grain bulk; if the grain is to be stored for more than one year, transfer it to a different bin every 10-12 months, preferably during cold winter weather.

Note: Scientific names appear in the footnote (p. 13) since none of the common names except that of Acarus siro *(grain mite) have been established as yet in the entomological literature.*

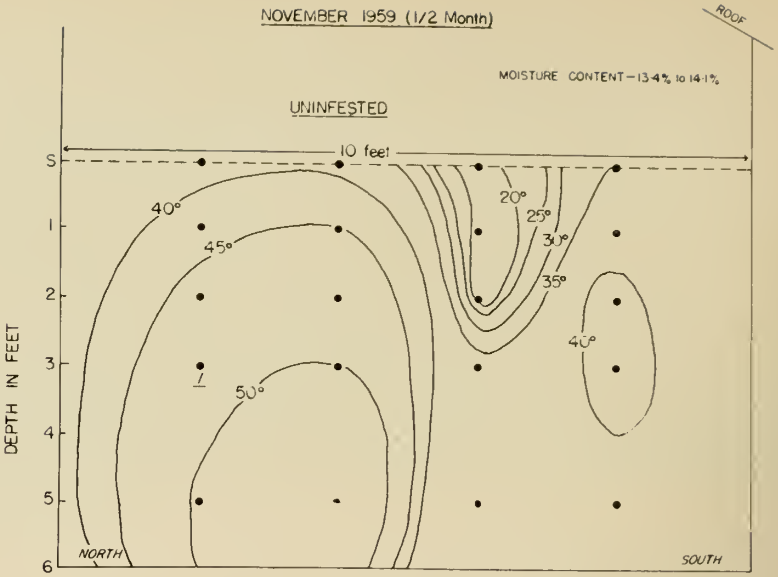


Fig. 1: November, 1959—infestation was low.

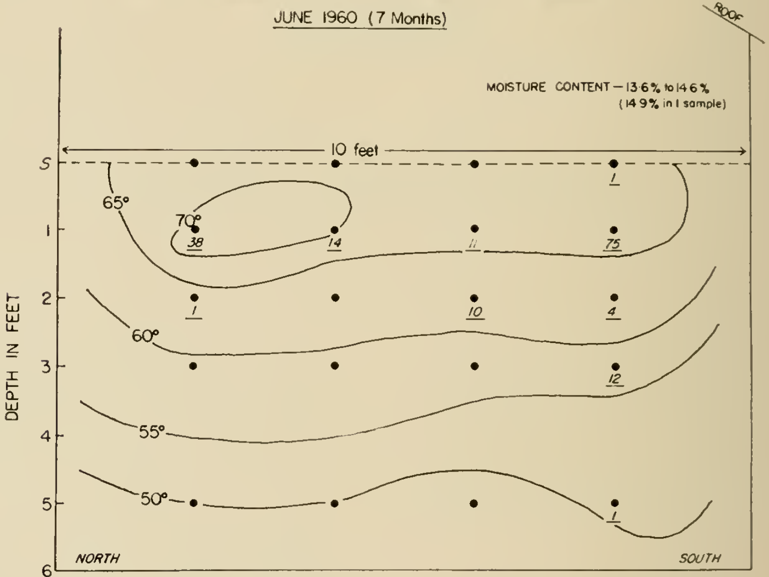


Fig. 2: June, 1960—infestation heavier, moisture content higher.

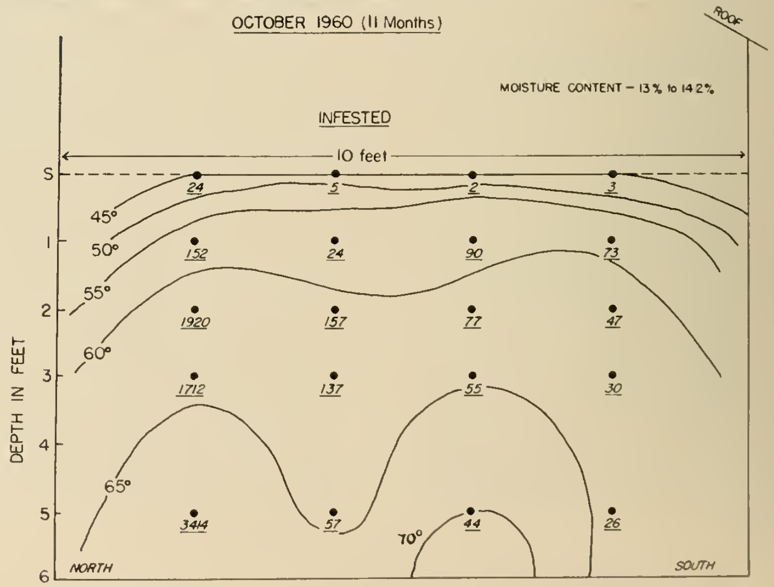
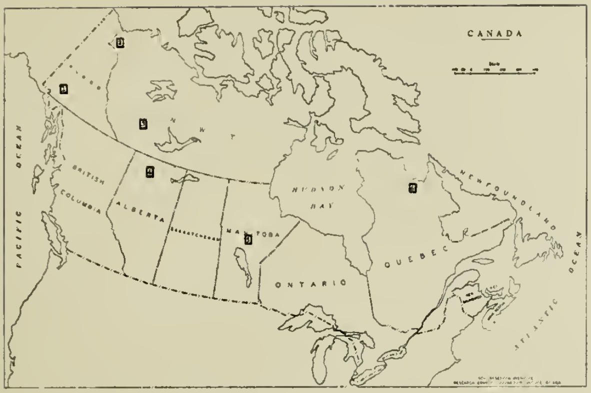


Fig. 3: October, 1960—infestation heavy and widespread; grain temperature from 45°-70°F., moisture content from 13%-14.2%.



Numbers on map relate to photos shown.

Glimpses:

Canada's Northern Agriculture

F. S. Nowosad

With the development of Canada's North there has come about a steady increase in population and a demand for agricultural information. While large-scale field crop production may be problematical, there will always be a demand for agricultural products such as fresh vegetables, milk, meat and eggs wherever the people live.

To study the agricultural possibilities of the area the Canada Department of Agriculture operates experimental stations at Mile 1019 on the Alaska Highway in Yukon, at Fort Simpson in the Northwest Territories; Fort Vermilion, Alberta; Wabowden, Manitoba, and at Fort Chimo, Quebec. In addition, numerous off-station and co-operative tests are conducted on the properties of certain residents in the more remote areas where farming is not generally practiced.

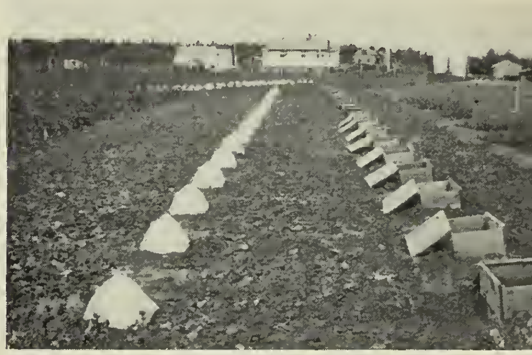
Agricultural surveys are in progress and some information is now available on the location and extent of good soils in Yukon and Northwest Territories, and in the northern parts of most provinces. Climatic conditions are under study and much is already known about the use of soils for the production of various crops and livestock.

Mr. Nowosad is a specialist in Northern Agriculture with the Program Directorate, Research Branch, Ottawa, Ont.

6. Pilgrim goslings (right) were airborne from Ottawa to Fort Chimo, Que. and three weeks later put on tidal flats pasture at nearby False River. Eskimo women (left) are pleased with these geese, some weighing 13 lb. by mid-September.

1. Mile 1019, Alaska Highway, Whitehorse, Yukon. Plastic shelters used in flower growing. *Inset:* Crops grown here.

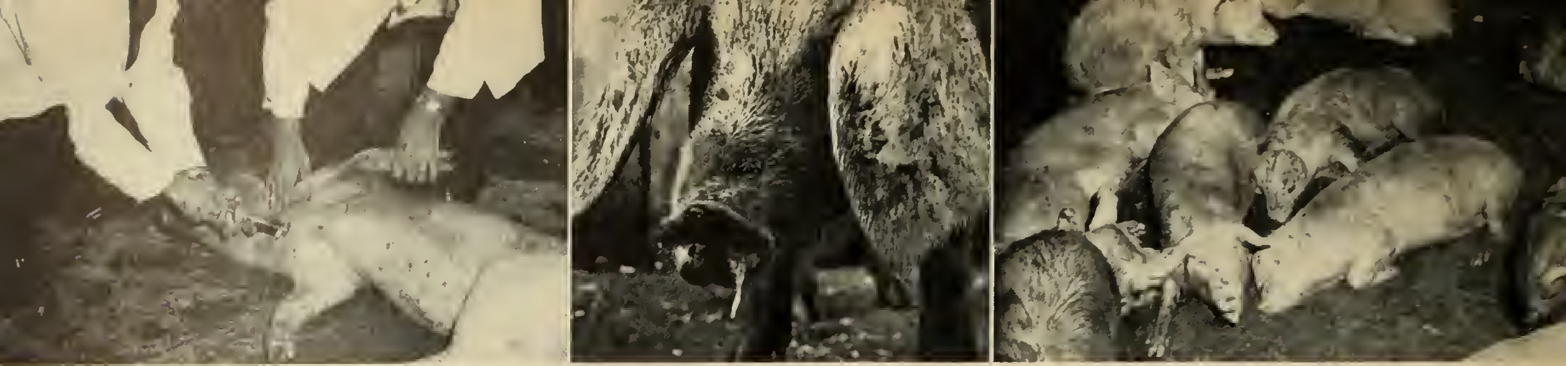
2. Inuvik, 127 miles north of Arctic Circle. Experimental plot on perma frost produces most garden crops after three years.



3. Fort Simpson, N.W.T. Protection from spring frosts is being explored for cucumbers, melons and tomatoes.

4. Fort Vermilion, Alta. Plastic shelters used to guarantee crops of corn, tomatoes, cucumbers.

5. Wabowden, Man. (below). Excellent potato crops possible.



Left: Federal veterinarians, during recent outbreak, taking blood sample from cholera-suspected pig. Blood and tissue samples are sent to the Animal Diseases Research Institute, Hull, Que., for diagnosis. *Center and right:* Noticeable symptoms of hog cholera are a disinclination to move, refusal to eat, an arched back and a high temperature; paralysis of the hind legs may also occur.

HOG CHOLERA

Diagnosis by the animal neutralization test is time consuming and costly. Scientists at the Animal Diseases Research Institute are attempting to develop a serological test as a supplementary method of confirming diagnosis.

A. Zarkower AND G. L. Bannister

Hog cholera is an acute, highly contagious virus disease affecting swine of all ages. Newly weaned pigs are regarded as the most susceptible, and in these the mortality rate is frequently 100 per cent. The period of incubation varies from 3 to 10 days. The most noticeable symptoms are a disinclination to move, refusal to eat, an arched back and a high temperature. In some outbreaks paralysis, particularly of the hind legs, becomes marked. Small haemorrhages cause a red discoloration of the skin of the ears and abdomen. Mild forms of the disease may exist where few of the cardinal signs are seen.

Presently, the presumptive clinical diognosis of hog cholera is based upon the appearance of typical symptoms as described above and on pathological lesions indicative of the disease. Confirmatory diagnosis can be made only in the laboratory by means of an animal neutralization test. This consists of inoculating known susceptible and immune pigs with suspected material. If the virus is present in the material inoculated, a temperature rise and other symptoms will develop in the susceptible animals whereas the immunized pigs will remain unaffected. Since this method is time consuming and expensive, work is in progress at the Animal Diseases Research Institute to develop a serological test as a supplementary method of confirming diagnosis.

Due to the large scale importation of pork or pork products from the United States, where the disease is widespread, there is a constant danger of hog cholera being introduced into Canada. The farmer should be warned not to allow the pigs to have any contact with uncooked pork products. If he is licensed to feed garbage, he should take all precautions in cooking the material properly and using clean uncontaminated containers. In the case of an outbreak of any disease which may resemble hog cholera, a veterinarian should be called, who upon examination can take further steps if necessary.

The authors are specialists with the Animal Pathology Laboratories, Health of Animals Division, Animal Diseases Research Institute, Hull, Que.

Authors inoculating young pig used in a serum neutralization test for hog cholera diagnosis. Dr. Bannister (center) placing blood sample suspected of containing hog cholera virus in centrifuge for concentration. This is part of an attempt by A.D.R.I. scientists to develop a serological test as a supplementary method of confirming diagnosis. Dr. Zarkower (right) testing virus-sensitized cells in search of a suitable reagent for use in developing a serological test.

Roger Duhamel, f.r.s.c., Queen's Printer and Controller of Stationery, Ottawa, 1961